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Calvin L. Ferrell

U.S. Meat Animal Research Center

Dan B. Laster

USDA-ARS

Ronald L. Prior

Hastings, NE

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Mineral Accretion During Prenatal Growth of Cattle

Calvin L. Ferrell, Dan B. Laster and Ronald L. Prior¹

Introduction

Published data on prenatal (fetal) growth in cattle have been limited primarily to birth weights or weights and linear measurements of fetuses at different stages of gestation. Others have provided data describing fetal growth in terms of weight, nitrogen, and energy. These and other data have provided insight into the rates of protein and energy accumulation by the fetus during development and serve as bases for the estimation of protein and energy requirements for fetal development. Objectives of the present study were to describe the patterns of calcium (Ca), phosphorus (P), sodium (Na), potassium (K), magnesium (Mg), iron (Fe), and zinc (Zn) accretion in bovine fetuses and to estimate requirements of these minerals for pregnancy in cattle.

Procedure

Angus, Hereford, and Red Poll crossbred yearling heifers (732 lb) were mated to five half-sibling Brown Swiss bulls. Heifers (81 head) which were diagnosed pregnant at 35 to 42 days postmating were assigned on the bases of weight and breed cross to one of three pens and fed diets that were equal in nitrogen content to achieve maternal weights gains of approximately 0 (low), 1.1 (medium), or 2.2 (high) lb/day. Heifers (three to seven) from each treatment group were slaughtered at about 120, 150, 180, 210, 240, and 255 days postmating at a commercial facility.

Reproductive tracts were recovered at slaughter. Weights of each total gravid (pregnant) uterus, then weights of separate components—fetus, fetal fluids (allantoic and amniotic), uterus, cotyledons, and placenta (fetal membranes with cotyledons removed)—were obtained. Fetal sex was recorded. Fetuses were frozen at -29°F and later ground, mixed, and sampled. Dry matter was determined on duplicate samples by drying in a forced-air oven.

Duplicate samples of each fetus were ashed. Ashed samples were then analyzed for Ca, P, Na, Mg, Fe, and Zn content. Data were analyzed by regression analysis.

Results

Fetal weight and mineral content at different stages of gestation, estimated from regression analyses, are presented in Table 1. Ca and P contents of bovine fetuses increased with gestation. Others have observed a more rapid increase of these minerals in fetuses of dairy cows. The Ca to P ratio in this study was 1.1 at 100 days of gestation and increased to about 1.6 at 280 days, whereas previous data indicated the Ca to P ratio to be about 1.4 at 140 days and about 1.8 near term. The differences between these studies may be attributed largely to differences in the breeds of cattle involved. The results of this study demonstrated that the Ca to P ratio was not constant but increased as the fetus developed. These results were a reflection of the different distribution of Ca and P in the body as well as the different growth patterns of the different tissues.

Although total fetal Na and K contents increased during gestation (Table 1), Na concentration decreased. Others have observed that fetal Na concentration decreased but that K concentration increased during gestation.

The Mg content of bovine fetuses (Table 1) increased 200 fold from 100 days postmating to 280 days. Few data were

found for comparison with these values. The Fe content of bovine fetuses increased 160 fold from 100 to 280 days postmating. No data were found for comparison with these values. Zn content of bovine fetuses increased 160 fold from 100 to 280 days of gestation.

Daily rates of fetal weight, Ca, P, Na, K, Mg, Fe, and Zn gains (Table 2) at different stages of gestation were obtained by differentiation of the relationships between total fetal content of these minerals and days of gestation with respect to day of gestation. The values obtained were considered to be estimates of the rates of accretion of the various fetal components on different days postmating. These values indicated that daily rates of accretion of all fetal components increased during early and mid-gestation, reached a maximum at about 250 days and then decreased. Previously, we have observed a decline in the rate of increase in fetal weight, energy, and nitrogen gain, but did not observe an actual decrease in the rate of fetal growth. The observed decrease may have been due to a breed of sire \times breed of dam interaction and to parity of the dam. These data demonstrated that accretion rates in bovine fetuses of all minerals were small during the first two trimesters of gestation but relatively large during the last trimester.

Mineral accretion rates in nonfetal gravid uterine tissues were estimated from the rate of weight change in the uterus, fetal membranes, and fetal fluids at different stages of gestation and from literature values on the mineral contents of these tissues.

The accretion rates of each mineral in each nonfetal uterine tissue at each stage of gestation were combined with estimates of fetal mineral accretion. Results are presented in Table 3. Comparison of Table 3 to Table 2 reveals that mineral accretion in the nonfetal uterine tissues was small in relation to mineral accretion in the fetal component. Thus, even though errors may be associated with the estimates of non-fetal mineral accretion, these appear to be of little significance in relation to total gravid uterine mineral accretion.

Ca and P accretion rates in the gravid uterus (Table 3) were lower, especially during the latter stages of gestation, than reported by others. These differences appear to be due largely to the breeds of cattle used in the data base. Previously reported values were derived from estimates of the Ca and P contents of the fetuses from dairy cows and from gravid uterine growth curves of Red Danish cattle, both of which resulted in higher values late in gestation than observed in the crossbred fetuses used in this study. Rates of Na and K accretion in gravid uterine tissues were slightly lower than estimates obtained previously, but estimates of Mg accretion rates were much lower in this study. These estimates were based on estimates of the Mg content of calves at birth. This value is about twofold higher than that observed in the present study. No data were found for comparison with the Fe and Zn accretion rates observed in this study.

The rates of accretion of the various minerals in the gravid uterus provide estimates of minimal net amounts of the minerals evaluated that need to be available to the uterus for development of the gravid uterine tissues at various stages of gestation in cattle of similar type. Estimates of daily allowances of Ca, P, Na, K, Mg, Fe, and Zn (Table 4) were calculated assuming availabilities of 45, 45, 100, 100, 20, 50, and 50 percent, respectively. It should be recognized that availabilities vary depending on mineral source, maturity, physiological state of the animal, etc. Ca availability, for example, may range from about 20 to 100 percent.

The data provide estimates of daily allowances of several minerals for pregnant beef cattle. The allowances obtained should be added to maternal allowances to obtain estimates of total mineral allowances during pregnancy in cattle.

¹Ferrell is a research animal scientist, Nutrition Unit, MARC; Laster is associate deputy administrator, National Program Staff USDA-ARS, Beltsville, Maryland (formerly the research leader, Reproduction Unit, MARC); and Prior is self-employed in Hastings, Nebraska (formerly a research chemist, Nutrition Unit, MARC).

Table 1.—Weights of various fetal components at various stages of gestation^a

Day of gestation	Fetal								
	Weight, lb	Ca, g	P, g	Na, g	K, g	Mg, g	Fe, g	Zn, g	
100	.77	1.11	1.00	.69	.55	.054	.015	.004	
130	2.7	5.05	3.96	2.35	1.96	.203	.056	.017	
160	7.8	18.3	12.9	6.62	5.71	.645	.172	.057	
190	18.8	53.1	34.6	15.3	13.7	1.71	.442	.153	
220	37.7	123	76.2	29.2	26.8	3.80	.943	.331	
250	63.1	227	138	45.9	43.2	7.07	1.67	.577	
280	87.5	334	205	59.3	57.1	11.0	2.46	.810	

^a1g = .0022 lb.

Table 2.—Daily weight gain and mineral gain by the bovine fetus at various stages of gestation^a

Day of gestation	Fetal								
	Weight, g	Ca, g	P, g	Na, g	K, g	Mg, mg	Fe, mg	Zn, mg	
100	16	.06	.05	.030	.025	3	7	.2	
130	47	.24	.17	.089	.076	8	2.3	.7	
160	115	.72	.47	.207	.185	23	5.9	2.1	
190	224	1.68	1.02	.380	.352	51	12.5	4.5	
220	345	2.97	1.75	.534	.515	90	20.9	7.3	
250	400	3.78	2.27	.542	.545	125	26.7	8.6	
280	313	3.07	2.04	.316	.343	129	24.2	6.2	

^a1g = .0022 lb.

Table 3.—Daily mineral gain by the bovine uterus at various stages of gestation.

Day of gestation	Gravid uterine component ^a							
	Ca, g	P, g	Na, g	K, g	Mg, mg	Fe, mg	Zn, mg	
100	.07	.08	.18	.08	8	4.9	1.5	
130	.25	.21	.27	.14	15	7.4	2.3	
160	.73	.53	.41	.26	32	12.1	3.1	
190	1.69	1.09	.61	.44	61	19.6	6.7	
220	2.98	1.82	.76	.61	101	28.1	9.6	
250	3.79	2.34	.76	.63	124	32.8	10.5	
280	3.08	2.09	.48	.41	136	28.6	7.6	

^a1g = .0022 lb, 1mg = .001 g.

Table 4.—Estimated daily allowances of various minerals for pregnancy in cattle^a

Day of gestation	Ca, g	P, g	Na, g	K, g	Mg, mg	Fe, mg	Zn, mg
100	.16	.18	.18	.08	.04	9.8	3.0
130	.56	.47	.27	.14	.08	14.8	4.6
160	1.62	1.18	.41	.26	.16	24.2	6.2
190	3.76	2.42	.61	.44	.31	39.2	13.4
220	6.62	4.04	.76	.61	.51	56.2	19.2
250	8.42	5.20	.76	.63	.62	65.4	21.0
280	6.84	4.64	.48	.41	.68	57.2	15.2

^aAvailabilities used to estimate allowances of various minerals were: Ca, 45 percent; Na, 100 percent; K, 100 percent; Mg, 20 percent; Fe, 50 percent; Zn, 50 percent. See text for details.